

ULS Systems Research Roadmap

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

March 2008



Software Engineering Institute

Carnegie Mellon

© 2008 Carnegie Mellon University

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE MAR 2008		2. REPORT TYPE		3. DATES COVERED 00-00-2008 to 00-00-2008	
4. TITLE AND SUBTITLE ULS Systems Research Roadmap				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Carnegie Mellon University ,Software Engineering Institute (SEI),Pittsburgh,PA,15213				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES presented at the 2008 SMART Ultra-Large-Scale System Forum, Pittsburgh, PA, 6 Mar 2008.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 23	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Roadmap Intent

Help evaluate the ULS systems relevance of existing or planned research

- The roadmap structure explicitly shows a ULS system perspective

Prioritize research funding

- The roadmap provides a basis for determining which research is most critical/relevant/impactful for achieving a future ULS systems capability

Framework for incorporating additional ULS systems research

Motivate Research

- The roadmap shows how an individual research initiative supports one or more ULS-system technical challenges

Put Research in Context



The Roadmap Root: A Warfighter Capability

The ULS System report mentioned six capabilities needed by the DoD

The roadmap combines two of them (C1/C6) into a single capability to show research relevance to desired military capabilities

- **Common Relevant Operational Picture (CROP):** Maintain coherent common operating picture
 - across echelons, services, and coalitions in a mix of ultra-large-scale environments (C1)
 - applying local context to global information sources to ensure use of the right data any time, any place, for any mission (C6)



A Needed Warfighter Capability

Common Relevant Operational Picture: Maintain coherent common operating picture by rapidly collecting, processing, disseminating, and protecting information spanning echelons, services, and coalitions across a mix of ultra-large-scale environments. Apply local context to global information sources to ensure use of the right data any time, any place, for any mission.



Technical Observations

Common Relevant Operational Picture: Maintain coherent common operating picture by rapidly collecting, processing, disseminating, and protecting information spanning echelons, services, and coalitions across a mix of ultra-large-scale environments. Apply local context to global information sources to ensure use of the right data any time, any place, for any mission.

Different users have different info needs based on their role and context

User needs for info change dynamically

System connectivity and info flow changes dynamically

People will (mis)use the system in unexpected ways, stressing HW and SW

CROP capability evolves non-uniformly in its structure, components, and uses



Roadmap Example

Observation

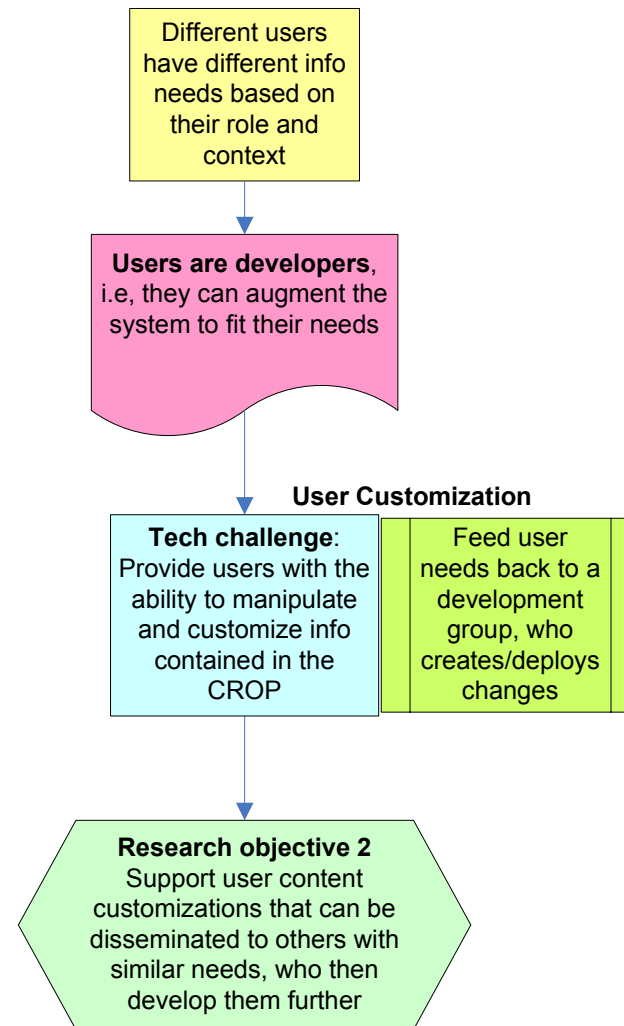
Different users
have different info
needs based on
their role and
context



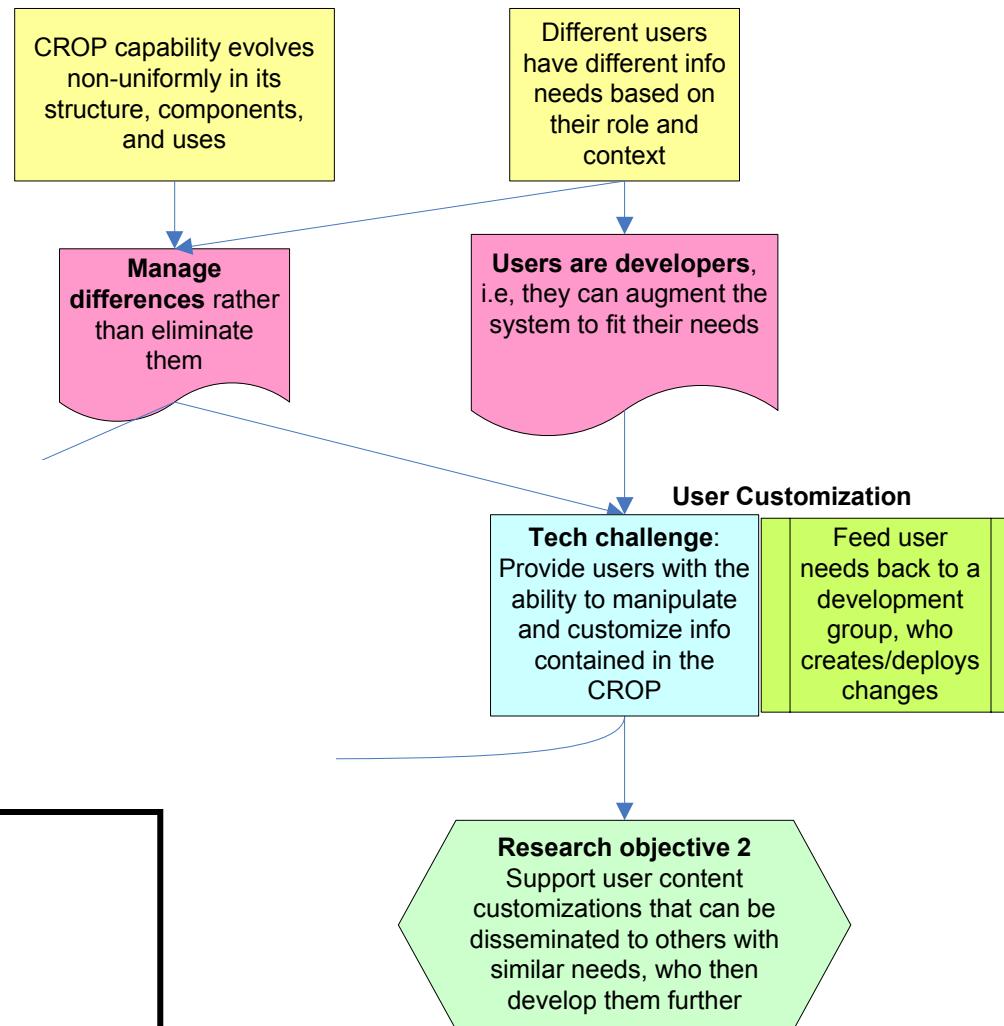
ULS System Perspectives

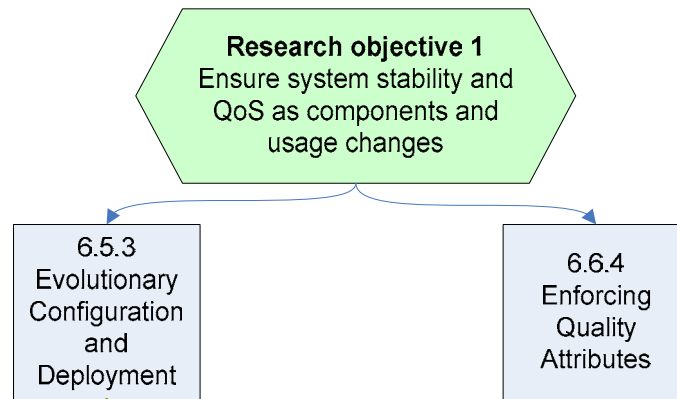


Previous Roadmap Example



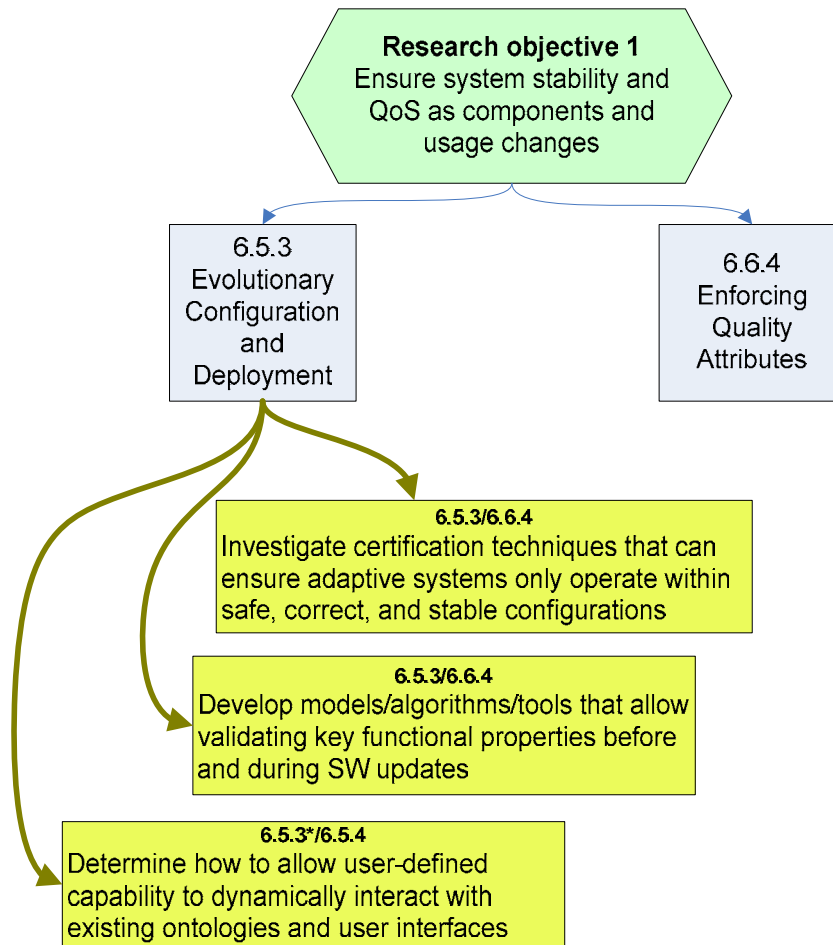
Augmented Roadmap Example





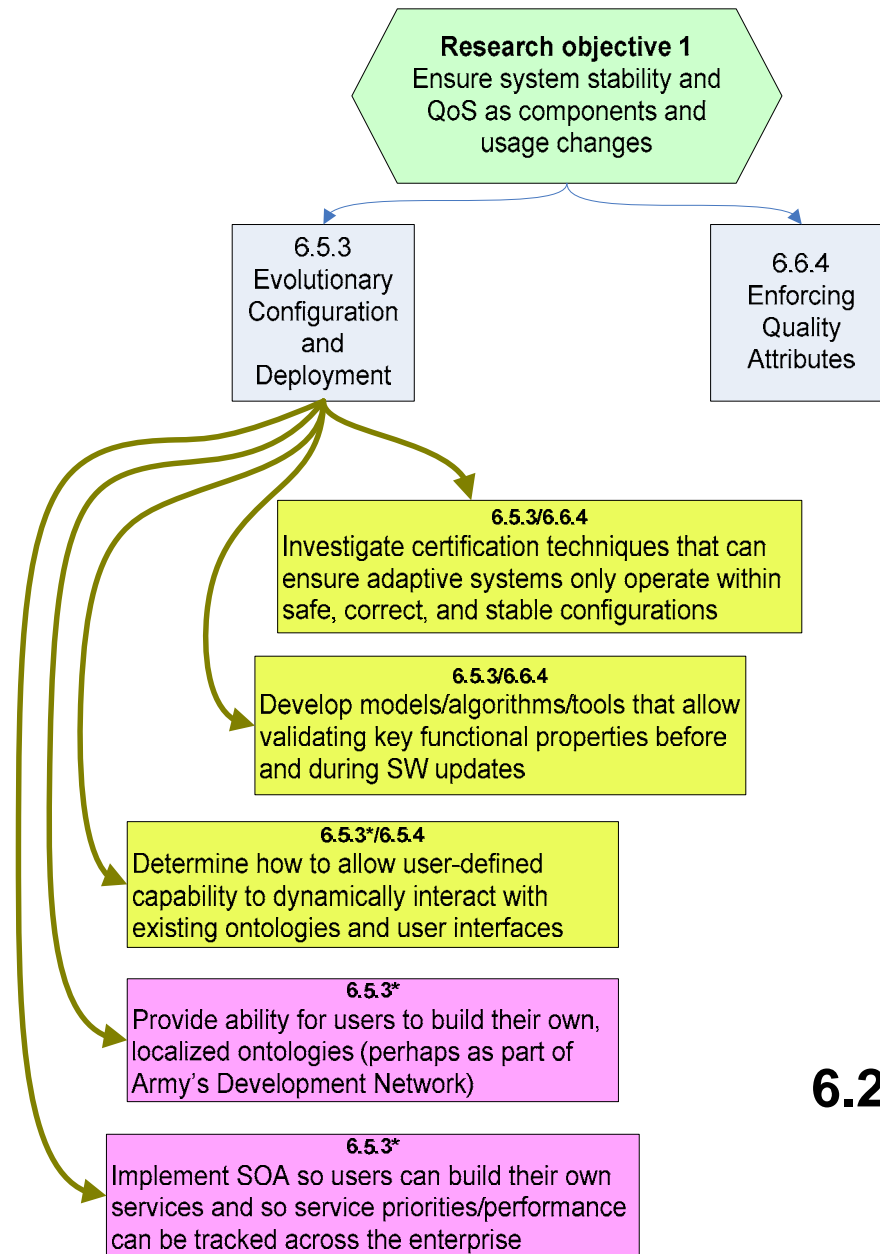
Research Topic from ULS Systems Report





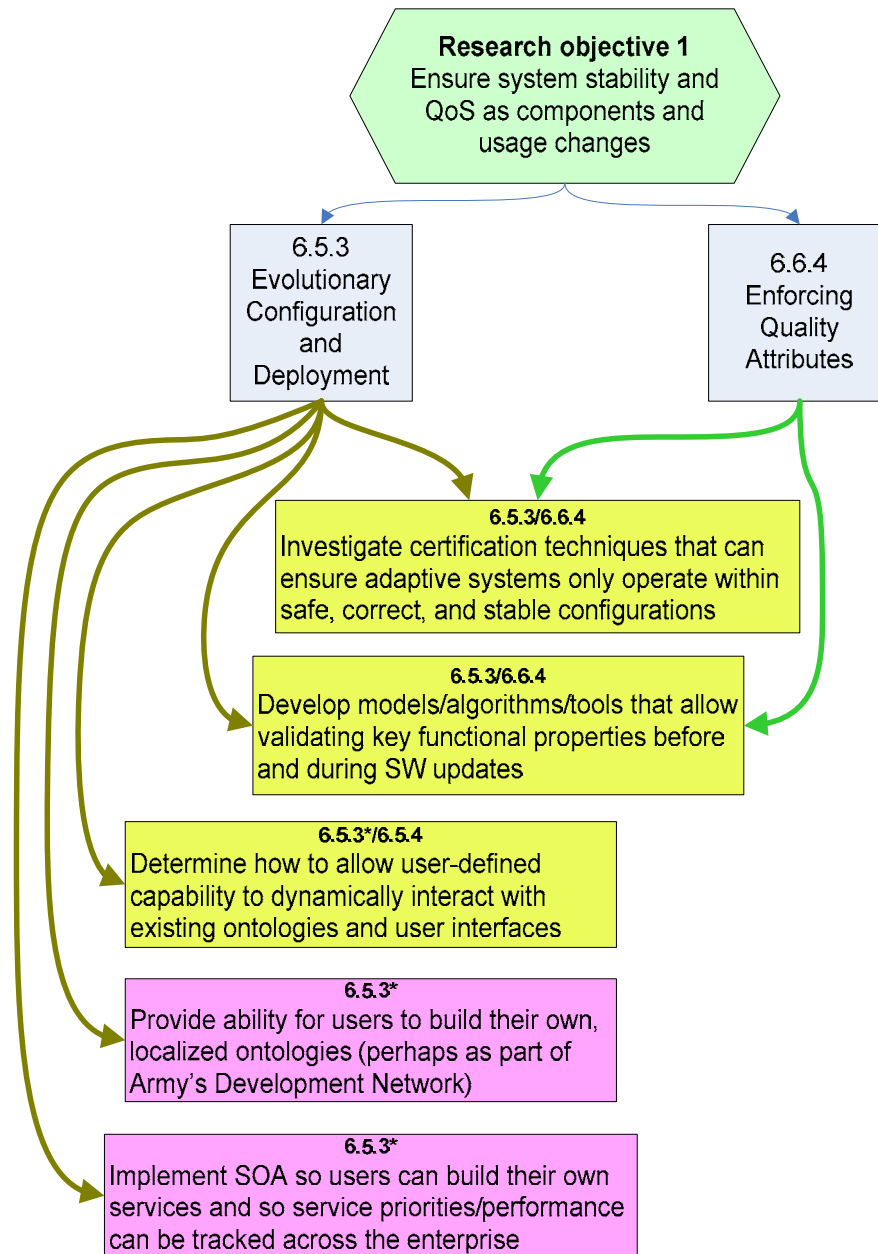
6.1 Research

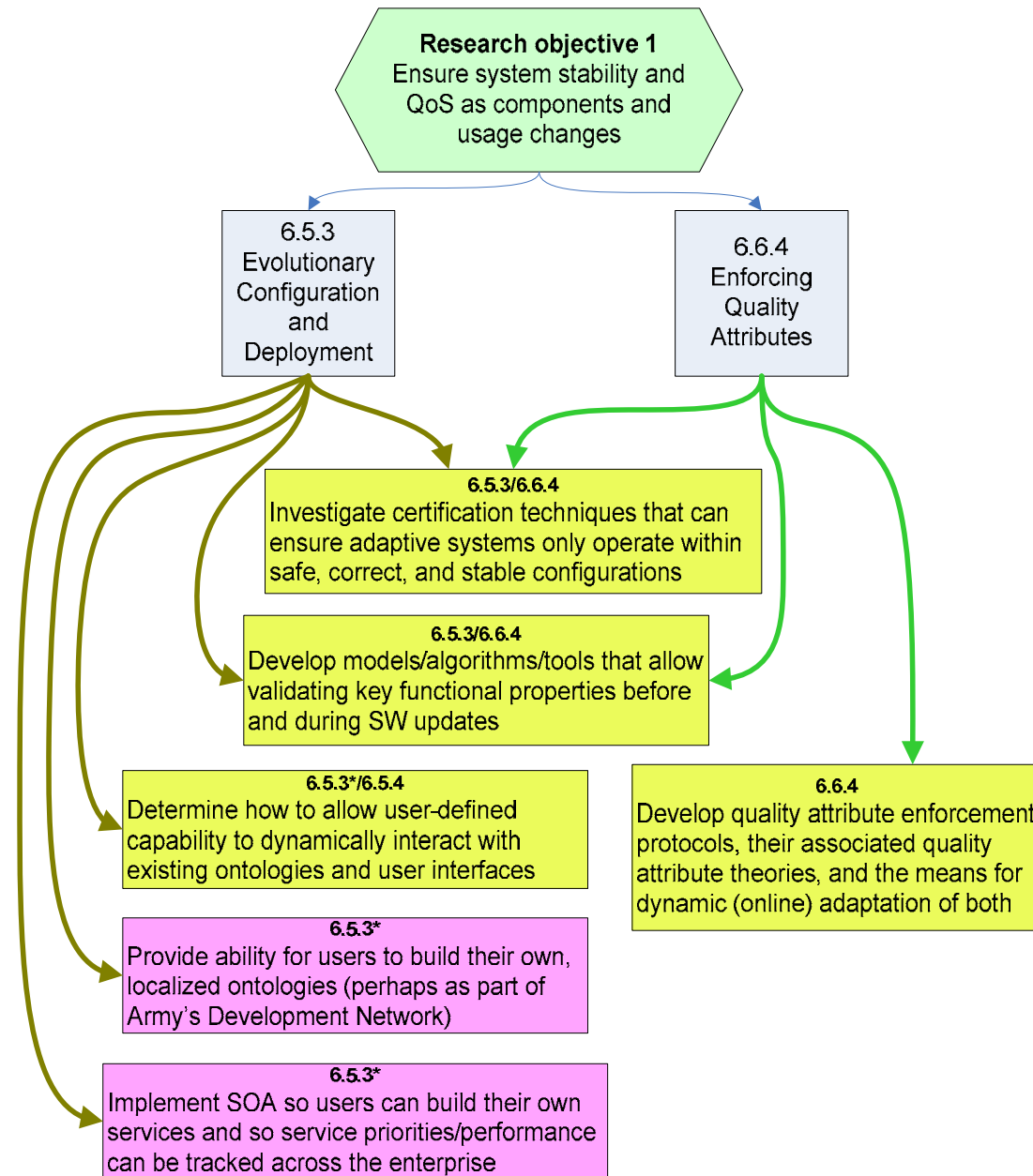


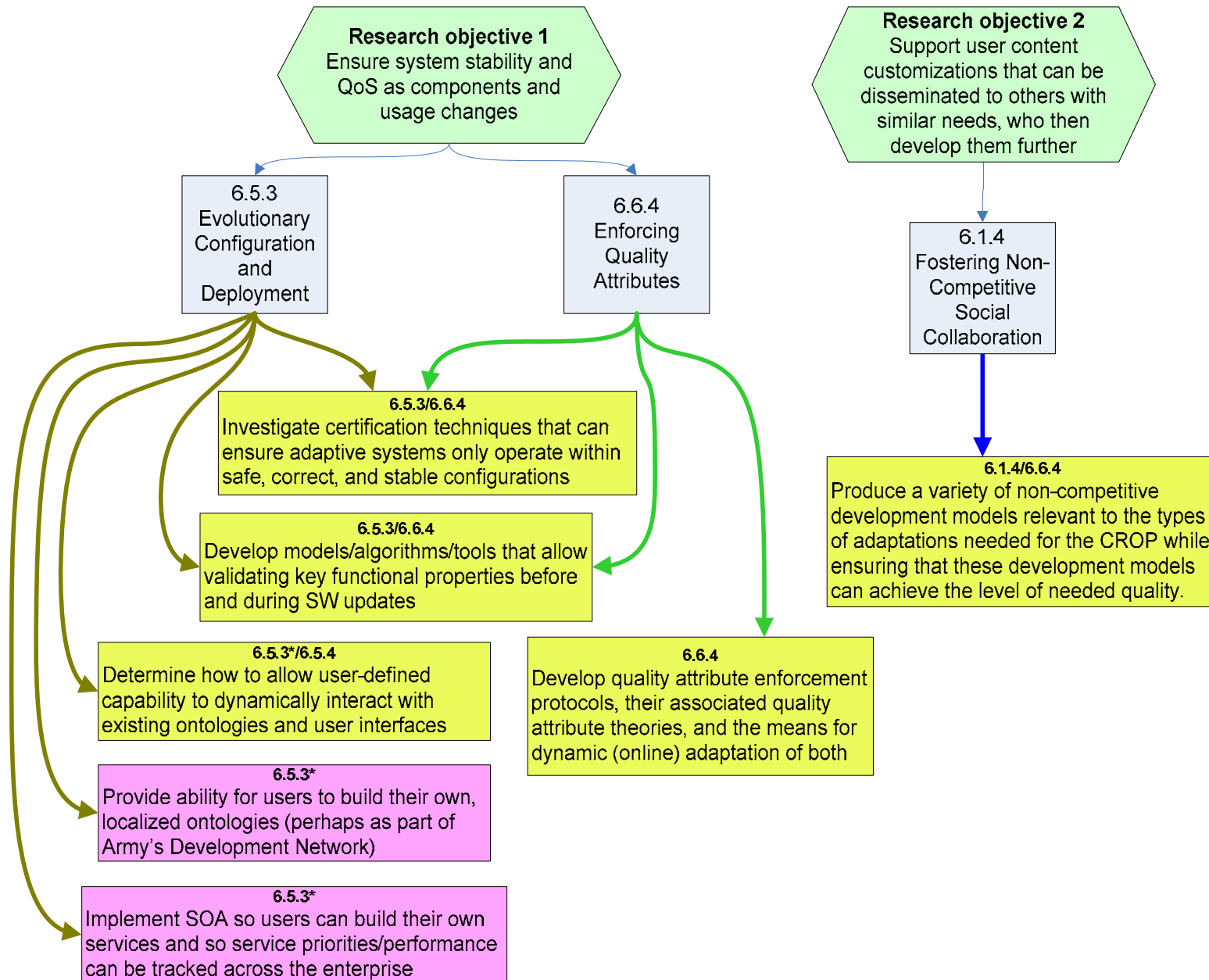


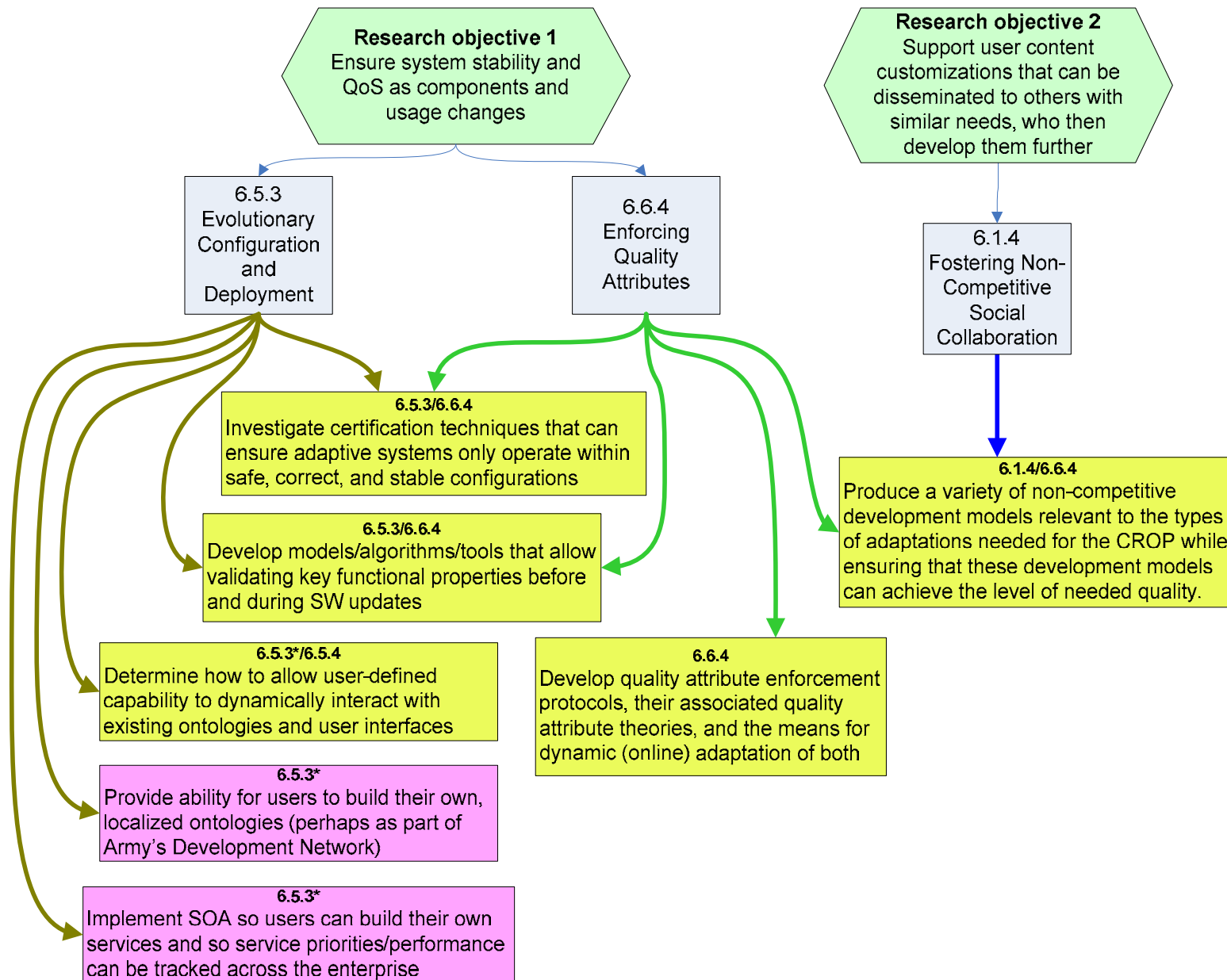
6.2/3 Research











Roadmap Structure and Development Process

Start with: a needed ULS system capability

Make: Observations about this capability

- Example: user needs change dynamically

Use: ULS systems perspective (contrasted with conventional approach)

Identify: Technical challenge (related to ULS systems perspective)

- Contrast with the “usual” technical challenge

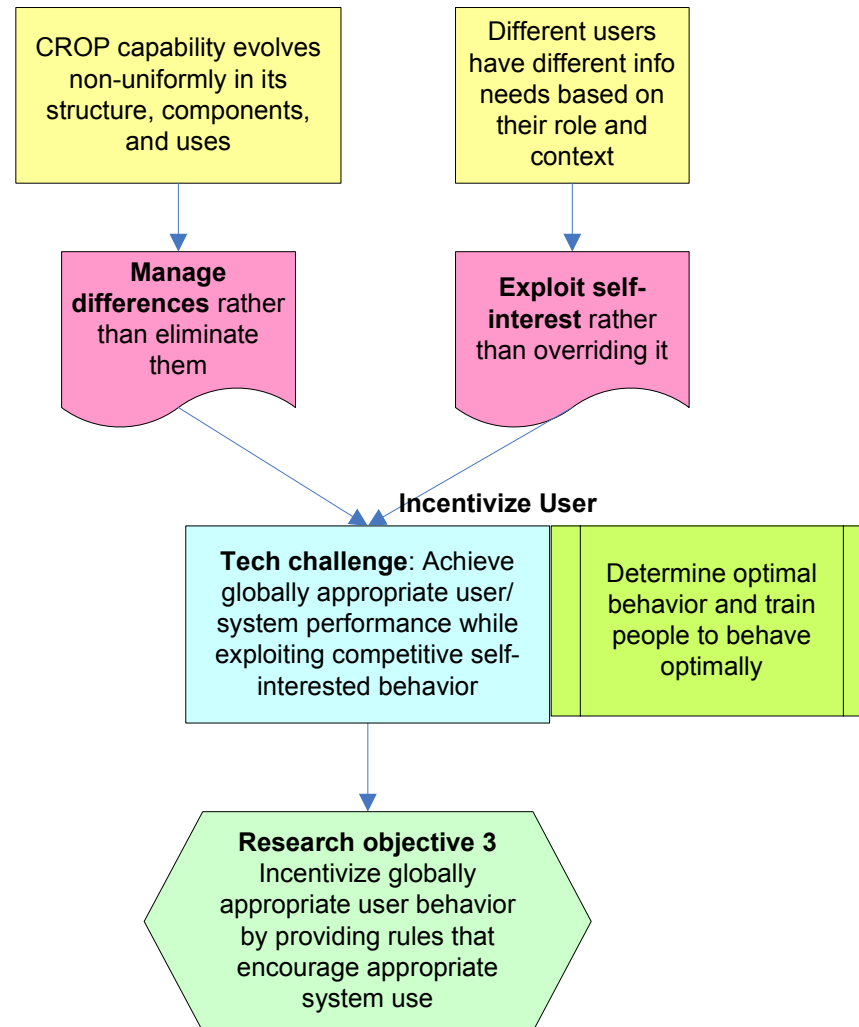
Restate challenge as: Research objective

Cite: ULS Systems report Research Topic

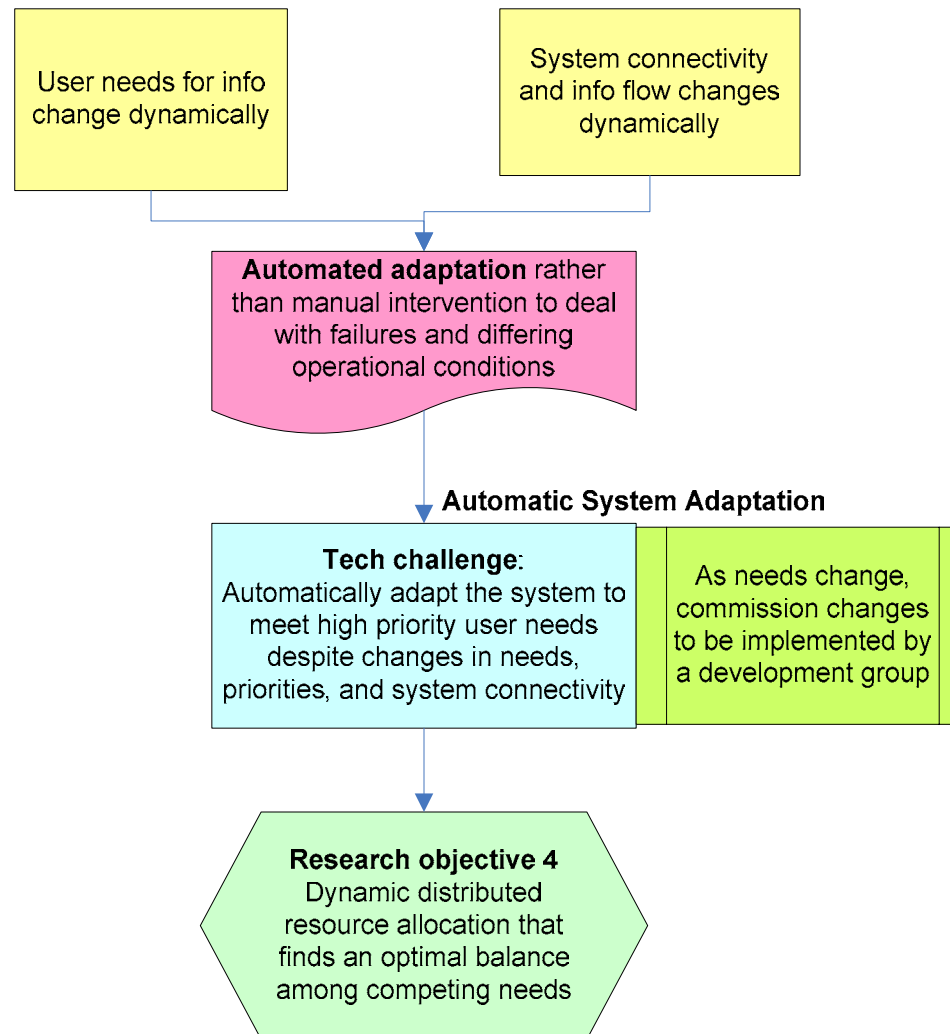
Define Research Initiatives: Several supporting each research objective



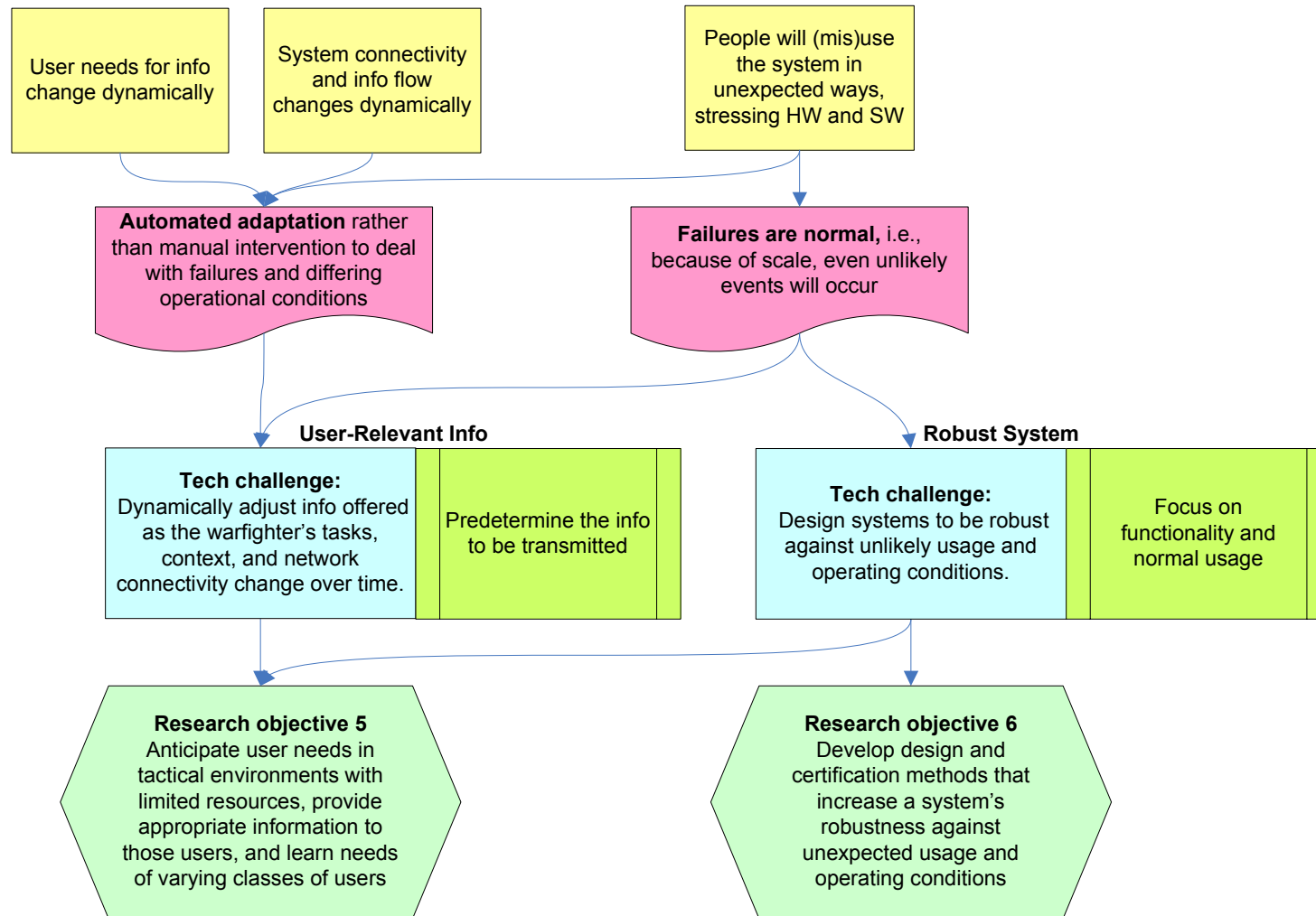
Incentivize User



Automatic System Adaptation



User Relevance and Robustness



ULS Systems Research Topics *In/Not In* Roadmap

6.1.1 Context-Aware Assistive Computing

6.1.2 Understanding Users and Their Contexts

6.1.3 Modeling Users and User Communities

6.1.4 Fostering Non-Competitive Social Collaboration

6.1.5 Longevity

6.2.1 Algorithmic Mechanism Design

6.2.2 Metaheuristics in Software Engineering

6.2.3 Digital Evolution

6.3.1 Design of All Levels

6.3.2 Design Spaces and Design Rules

6.3.3 Harnessing Economics to Promote Good Design

6.3.4 Design Representation/Analysis

6.3.5 Assimilation

6.3.6 Determining and Managing Requirements

6.4.1 Expressive Representation Languages

6.4.2 Scaled-Up Specification, Verification, and Certification

6.4.3 Computational Engineering for Analysis and Design

6.5.1 Decentralized Production Management

6.5.2 View-Based Evolution

6.5.3 Evolutionary Configuration and Deployment

6.5.4 In Situ Control and Adaptation

6.6.1 Robustness, Adaptation, and Quality Attributes

6.6.2 Scale and Composition of Quality Attributes

6.6.3 Understanding People-Centric Qual. Attr.

6.6.4 Enforcing Quality Requirements

6.6.5 Security, Trust, and Resiliency

6.6.6 Engineering Management at Ultra-Large Scales

6.7.1 Policy Definition for ULS Systems

6.7.2 Fast Acquisition for ULS Systems

6.7.3 Management of ULS Systems



Roadmap Intent

Help evaluate the ULS systems relevance of existing or planned research

- The roadmap structure explicitly shows a ULS system perspective

Prioritize research funding

- The roadmap provides a basis for determining which research is most critical/relevant/impactful for achieving a future ULS systems capability

Framework for incorporating additional ULS systems research

Motivate Research

- The roadmap shows how an individual research initiative supports one or more ULS-system technical challenges

Put Research in Context





Software Engineering Institute

Carnegie Mellon